Tadashi BANDO*: *Haplotaenium*, a new genus separated from *Pleurotaenium* (Desmidiaceae, Chlorophyta)**

坂東忠司*: コウガイチリモ属（緑藻綱）より分離設立の新属ヒトツオビコウガイ属

The genus *Pleurotaenium* emended by Grönblad (1924) has been accepted by most of the subsequent authors, and at present, about 50 species of *Pleurotaenium* are known in the world. However, some species of the "*minutum*-group" (Krieger 1937), which cannot be applied to the original concept (e.g. "with the parietal chloroplasts") of *Pleurotaenium* (Nägeli 1849), have been included in this genus with reasons not given.

In the present study, the morphology of chloroplasts, the disposition of the pyrenoids, the density and size of mucilage pores and the shape of zygospores were examined in detail on many species belonging to *Pleurotaenium*. The results indicate that the species of the "*minutum*-group" should not be assigned to *Pleurotaenium*. A new genus *Haplotaenium* is therefore proposed for those species and separated from *Pleurotaenium*.

Material and methods Samples used in this study were collected from various localities of Japan and totaled to about 2,000. After brief observation of the living specimens, they were preserved in 1–2% commercial formalin for further studies. The fixed samples studied are deposited in the Herbarium of Hiroshima University (HIRO).

As many clones as possible were isolated from the algae containing samples at the field stations or laboratory for further examination immediately after they were collected. Each cell isolated was inoculated into a capped test tube containing 10 ml of CA medium (Ichimura & Watanabe 1974) or soil-water medium (Pringsheim 1946), and then cultured under the standard conditions: temperature 20±2°C, illumination ca 3,000 lux intensity provided by white fluorescent tube, and a 12 hr diurnal light-dark cycle.

* Department of Botany, Faculty of Science, Hiroshima University, Higashi-senda-machi 1-1-89, Hiroshima 730. 広島大学 理学部植物学教室.

** A part of a dissertation submitted in partial fulfillment of the requirement for the degree of Doctor of Science of the Hiroshima University.

The mutual distance, size and density of mucilage pores were measured from the photomicrographs made with the light microscope and SEM. To avoid overestimation, non-sloping parts of the subject were used in all measurements. Some data of the density of mucilage pores per 100 μm^2 were calculated with an expression ($200/\sqrt{3}\cdot d^2$; d=mean distance between pores) based on the supposition that each pore is surrounded by six pores arranged in systematic hexagon (Fig. 1). The availability of this expression was confirmed by comparing with the results of the actual surveys.

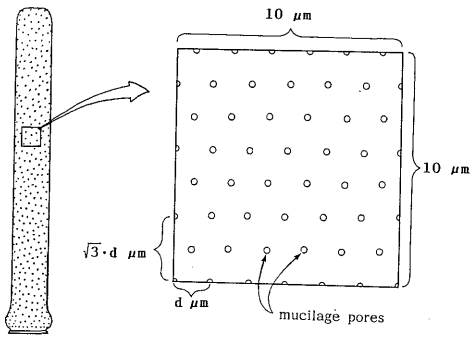

Fig. 1. Schematic arrangement of mucilage pores. Calculated density of mucilage pores per 100 μm^2 $=200/\sqrt{3}\times d^2$; d=mean distance between pores obtained from the actual surveys of photo-micrographs.

Observations of the chloroplasts, pyrenoids and terminal vacuoles were made by optical section under a light microscope. In some species, Rosowski's staining methods (Nisizawa & Chihara 1979) were employed to confirm the arrangement of pyrenoids.

Results and discussion The distance between mucilage pores and the density and diameter of pores were examined for many species (Tab. 1). The mucilage pores of the *minutum*-group are considerably denser and smaller than those of other pleurotaenia. The mucilage pores are somewhat denser at the apical part, and the results show that the size and numbers of pores are somewhat variable, but these features seem to be extremely useful as taxonomical characters.

Couté & Tell (1981) reported some data on the density of mucilage pores of *Pleurotaenium*. According to their observation, the cell wall of *P. wallichianum* (as *P. caldense* var. *cristatum*), *P. ehrenbergii* var. *ehrenbergii*, *P. ehrenbergii* var. *undulatum*, *P. subcoronulatum* and *P. verrucosum* possess pores with the following density: 36-42, 32-34, 12-14, 20-23 and 54-60 pores per 100 μm^2, respectively. These values are rather higher than those obtained in the present study. This discrepancy may be due to the difference in the measuring method.

Tab. 1. Variation of mucilage pore characters in selected species of *Pleurotaenium*.

Species	Distance between pores (μm)			Density of pores (no./100 μm^2)			Diameter of pores (μm)
	n	$\bar{x}$	SD	n	$\bar{x}$	SD	
P. minutum var. *minutum*	20	1.2	0.2	16	91.6	15.0	0.03–0.06
P. minutum var. *gracile*	20	1.2	0.1	10	83.5	13.9	0.04–0.06
P. rectum	20	1.4	0.2	7	57.4	8.0	0.03–0.05
P. simplicissimum var. *insigne*	20	2.2	0.4	17	25.9	3.5	0.14–0.16
P. ehrenbergii	20	2.3	0.3	15	22.9	1.7	—
P. trabecula	20	2.6	0.3	14	16.9	2.1	—
P. verrucosum var. *coronatum*	20	2.7	0.3	7	15.5	2.1	—
P. ovatum	20	3.1	0.4	12	12.3	1.1	—
P. archerii	20	3.0	0.5	12	11.8	0.9	—
P. wallichianum	20	3.5	0.5	16	9.5	1.8	0.10–0.17
P. subcoronulatum	20	3.6	0.3	10	9.3	0.8	—
P. nodosum	20	3.6	0.4	17	8.7	1.3	—
P. truncatum	20	3.6	0.3	39	8.6	1.3	0.11–0.18
P. maximum	20	3.4	0.3	8	7.8	1.3	—
P. abeanum var. *submagnum*	20	4.2	0.3	32	6.6	0.9	0.21–0.35
P. granuliferum	20	4.8	0.4	98	5.0	0.8	0.28–0.49
P. alternans	20	4.9	0.3	10	4.7	0.7	—

n: Number of specimens. $\bar{x}$: Mean. SD: Standard deviation.
The first three taxa are of the *minutum*-group.

In many other green algae, including some desmids such as *Mesotaenium*, *Spirotaenia*, *Genicularia*, *Actinotaeninm* and *Groenbladia*, the shape of the chloroplasts is one of the most important characters for the intergeneric classification. However, the chloroplast characters are now not fully used in the taxonomy of many other desmids.

In the present study, two major types of chloroplasts: "axile" (situated in

the center or axis of the cell) and "parietal" (pertaining to the wall), were recognized among pleurotaenia under light microscope (Fig. 2: 1-5). The axile chloroplast in the strict sense, refers to the chloroplast containing most of its chlorophyll around the vertical axis where pyrenoids are usually situated. The parietal chloroplast has most of its photosynthetic mass and pyrenoids at the distal part of the cell adjacent to the wall. The single axial chloroplast was observed in the members of the *minutum*-group, while the parietal chloroplasts were observed in all of the other species of *Pleurotaenium*.

The species of *Pleurotaenium* other than the *minutum*-group have 2 to 18 chloroplasts in each semicell, and the positive correlation is clearly recognized between the maximum widths of cells and the number of chloroplasts. On the other hand, the species of the *minutum*-group usually have a single chloroplast in each semicell. Even when these cells are broader than those of *Pleurotaenium*, their chloroplasts never increase in number. For example, the cells of *Pleurotaenium rectum* of the *minutum*-group are usually broader (17-22.5 μm) than those of *P. excelsum* var. *angustum* (12-16 μm), but the former usually has a single chloroplast and the latter usually has two chloroplasts.

The terminal vacuole occurring at each end of the cell has been found in many species of the desmidean genera, e.g. *Penium*, *Closterium* and *Pleurotaenium*. The species of *Pleurotaenium* have rather large and spherical terminal vacuoles which usually contain many clearly visible crystals in a state of agitation probably caused by Brownian movement (Fig. 2: 6, 7). The terminal vascuoles were shown by Ralfs (1848), Delponte (1878) and Hansgirg (1888) in their illustrations of *Pleurotaenium minutum* and *P. rectum*, both being the *minutum*-group. However, these illustrations are very questionable because since then no one has described such cells with terminal vacuoles for *P. minutum* and *P. rectum*. In the present study, careful examination was made for the *minutum*-group using both wild and cultured specimens in various ways, but no such vacuoles were observed in any of these cells.

The information on the zygospores of desmids is rather little. In the present study, zygospores were obtained from cultured and/or wild *P. trabecula*, *P. archerii* var. *elongatum*, *P. ehrenbergii* var. *mediolaeve*, *P. cuyabense*, *P. wallichianum*, *P. subcoronulatum* var. *africanum* and *P. alternans*. Their zygospores were similar to one another in shape. They were spherical or oval and lacked any protuberance on the surface. Some of them are shown in Fig. 3.

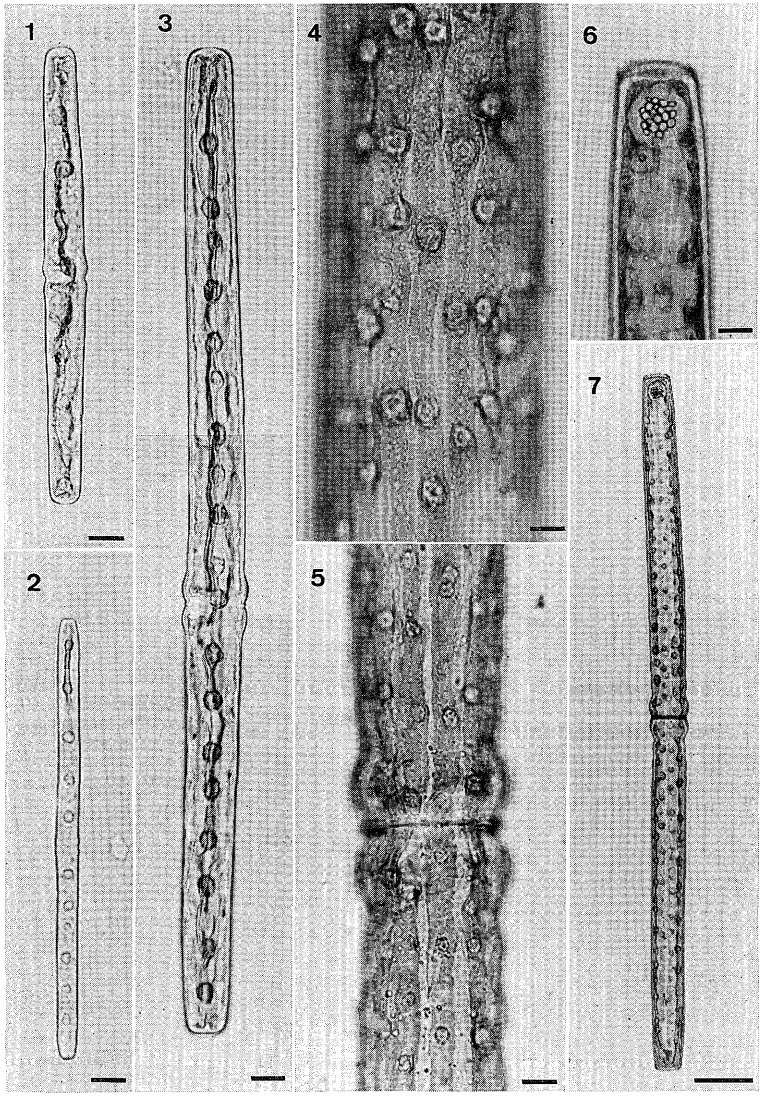

Fig. 2. Chloroplasts, pyrenoids and terminal vacuoles in some species (1 to 3 are of the *minutum*-group) of *Pleurotaenium*. 1-3. Axile chloroplasts and pyrenoids on the longitudinal axis. (1. *Pleurotaenium minutum* var. *minutum*; 2. *P. minutum* var. *bourrellyi*; 3. *P. rectum*). 4-7. Parietal chloroplasts and terminal vacuoles. (4. *P. wallichianum*; 5. *P. archerii* var. *archerii*; 6, 7. *P. archerii* var. *elongatum*). Scales in 7=50 μm; in others=10 μm.

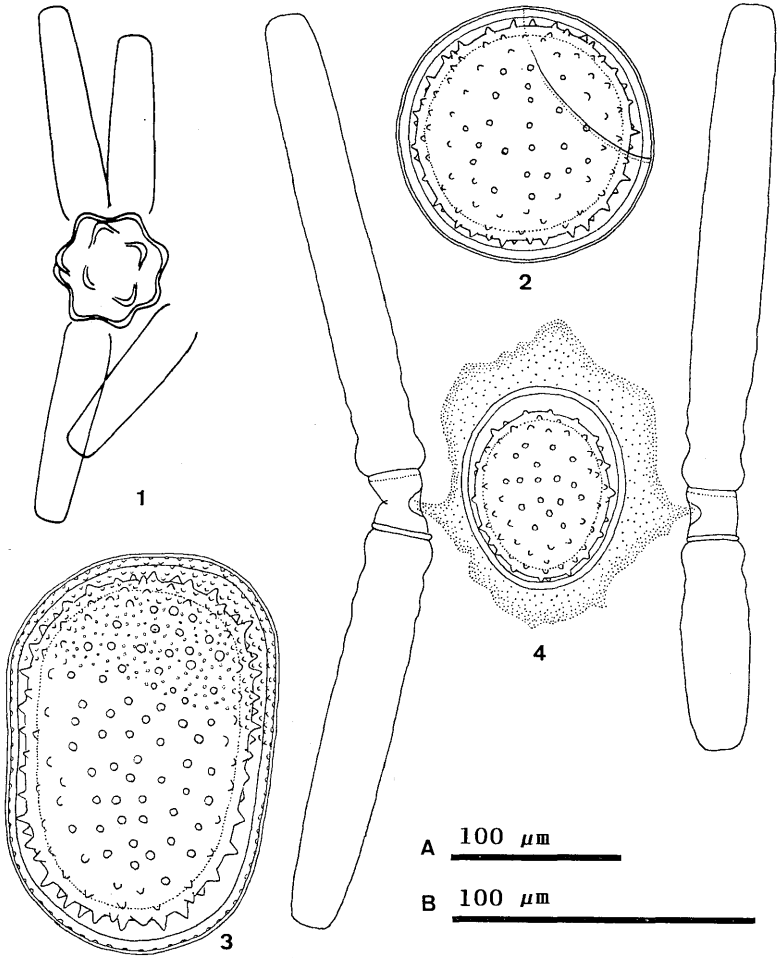

Fig. 3. Zygospores in some species of *Pleurotaenium*. 1. *Pleurotaenium minutum* (after Krieger, 1937). 2. *P. subcoronulatum* var. *africanum*. Showing an operculum for germination. 3. *P. ehrenbergii* var. *mediolaeve*. Showing the scrobiculate outer wall (upper half). 4. *P. archerii* var. *elongatum*. Scales A for 4; B for 1-3.

Immature zygospores were observed once in *P. cuyabense* and they were brownish green. When fully matured, an operculum for germination was observed in the zygospores from all the species examined. With the maturation of zygospores, their mesospore walls become mammillate and the color turns

into dark brown. In the *minutum*-group, there have been four reports on the zygospores, namely, in *P. rectum* by Kaiser (1914) and in *P. minutum* by Grönblad (1924) and Krieger (1932 & 1937). According to these authors, the zygospores of *P. minutum* are globose and covered with obtuse conical projections (Fig. 3: 1), a feature considerably similar to that of *Penium spinospermum* and *Closterium calosporum* rather than that of most other species of *Pleurotaenium*. Kaiser (1914) has reported a smooth and ellipsoid zygospore for *P. rectum*, but neither illustration nor detailed description is given. It may have been immature one.

Since *Pleurotanium minutum* was originally described by Ralfs (1848) as a species of *Docidium*, this species has been recombined by turns to several other genera, such as *Penium* (Cleve 1864), *Calocylindrus* (Kirchner 1878), *Pleurotaenium* (Delponte 1878), *Disphinctium* (Hansgirg 1888) and *Cosmarium* (Gutwinski 1891). This confusion had continued until Grönblad (1924) proposed the last resolution, applying this species and some other related species (i.e. those of the *minutum*-group) to *Pleurotaenium* by modifying the generic concept. According to the concept emended, the chloroplasts are axile or parietal and the terminal vacuole is not always present in the cell. It is clear that the features of the *minutum*-group differs entirely from those of the above mentioned genera except for the *Pleurotaenium*. Therefore, Grönblad's emended generic concept and his treatment has been accepted by most of the subsequent

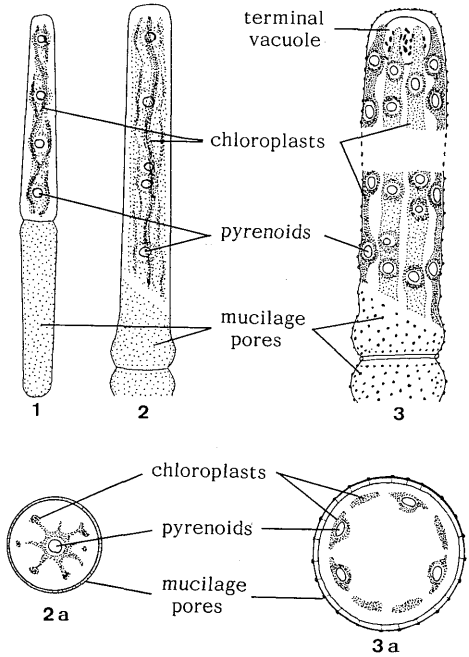

Fig. 4. Diagram showing the profile of the cell in species of *Haplotaenium* and *Pleurotaenium*. 1. *Haplotaenium minutum*. 2. *H. rectum* (2a; vertical view). 3. *Pleurotaenium trabecula* (3a; vertical view).

authors. However, to consider the results obtained in the present study, it is appropriate to remove the members of the *minutum*-group from *Pleurotaenium*. Thus, a new genus *Haplotaenium* is proposed to accommodate the *minutum*-group which includes *P. minutum* and *P. rectum*. The genus *Haplotaenium* is characterized by having axile chloroplast with a central row of pyrenoids, mucilage pores which are denser and smaller than those of *Pleurotaenium*, and lacking terminal vacuoles. These characters are schematically shown in Fig. 4.

Haplotaenium Bando, gen. nov.

Docidium Bréb. ex Ralfs, Brit. Desm. 155 (1848), *pro parte.*—*Pleurotaenium* Näg. *mut. char.* Grönbl., Acta Soc. Fauna Fl. Fen. **55**(3) : 5 (1924), *pro parte.*

Cellulae rectae, elongatae, circiter multo longiores quam lateriores, sectione transversa circulari paulo constrictae ad medium; semicellulae basali leviter inflatione vel saepe sine inflatione, longitudinaliter plicata nullo, lateribus rectis et subparalleis vel sensim attenuatae ad apices, apicibus truncato-rotundatis aut retuso, fere glabris; membrana gracilis, glabra vel subtiliter punctata; chloroplastus singularis, taeniis vel axialibus cum irregulariter et longitudinaliter lamina ex centro radiantibus, pyrenoidibus 2-15 in serie unica centrali ornatis; vacuo corpuscuo apicali nullo; zygosporae globosae, tectus obtusus conicis protuberantiae.

Typus: *Haplotaenium minutum* (Ralfs) Bando, comb. nov.

Enumeration of the Japanese representatives of *Haplotaenium*.

Haplotaenium minutum (Ralfs) Bando, comb. nov.

Basionym: *Docidium minutum* Ralfs, Brit. Desm., 158, t. 26, f. 5 (1848).

H. minutum (Ralfs) Bando var. **elongatum** (W. West) Bando, comb. nov.

Basionym: *Dicidium elongatum* W. West, Journ. R. Micr. Soc. **6**: 284, t. 5, f. 17 (1890).

H. minutum (Ralfs) Bando var. **gracile** (Wille) Bando, comb. nov.

Basionym: *Penium minutum* (Ralfs) Cleve var. *gracile* Wille, Norges. Ferskv. Alg. 51, t. 2, f. 33 (1881).

Haplotaenium bourrellyi (Grönblad et Scott) Bando, stat. et comb. nov.

Basionym: *Pleurotaenium minutum* (Ralfs) Delp. var. *bourrellyi* Grönblad et Scott., in Grönblad, Prowse & Scott, Acta Bot. Fen. **58**: 11, f. 2-3, photo 341 (1958).

Haplotaenium rectum (Delponte) Bando, comb. nov.

Basionym: *Pleurotaenium rectum* Delponte, Desm. Subalp. 129, t. 20, f.

8-11 (1878).

The detailed descriptions of these species will be reported in a separate paper.

I express my thanks to Dr. T. Nakano of Hiroshima University for his kind advice, and to Prof. Emer. H. Ando of the same university, Prof. M. Chihara of University of Tsukuba and Prof. Y. Hirahara of Hiroshima Jogakuin College for their critical reading and correction of the manuscript.

References

Cleve, P.T. 1864. Bidrag till kännedomen om Sveriges sötvattensalger af familjen Desmidieae. Öfvers. of K. Vet.-Akad. Förh. Arg. **20**(10): 481-497, pl. 4. Couté, A & G. Tell 1981. Ultrastructure de la paroi cellulaire des Desmidiacées au microscope électronique à balayage. Beih. Nova Hedwigia. **68**: 1-228. Delponte, J.B. 1878. Specimen Desmidiacearum subalpinarum. Mem. R. Acad. Sci. Torino, II, **30**: 1-186, pls. 7-23. Grönblad. R. 1924. Observations on some desmids. Acta Soc. Fauna Flora Fennica **55**(3): 1-18, 2 pls. Gutwinski, R. 1891. Flora Glonow Okolic Lwowa. Spraw. kom. Fizyjogr. Akad. Umiej. **27**: 28-75; 120-124, pls. 1-3. Hansgirg, A, 1888. Prodromus der Algenflora von Böhmen, I. Arch. f. Naturw. Landes. v. Böhmen **6**(6): 1-288. Ichimura, T. & M. Watanabe 1974. The *Closterium calosporum* complex from the Ryukyu Islands. Variation and taxonomical problems. Mem. Natn. Mus. **7**: 89-102, pls. 13, 14. Kaiser, P.E. 1914. Beiträge zur Kenntnis der Algenflora von Traunstein und dem Chiemgau, I. Ber. Bayer. Bot. Ges. **14**: 145-155. Kirchner, O. 1878. Algenflora von Schlesien. *In*: Cohn, F., Kryptogamenflora von Schlesien. Zweiten Bd., Erste Hälfte. Algen. 284 pp. Breslau. Krieger, W. 1932. Die Desmidiaceen der Deutschen Limnologischen Sunda-Expedition. Arch. f. Hydrobiol. suppl. **11**: 129-230, pls. 3-26. —— 1937. Die Desmidiaceen Europas mit Berücksichtigung der aussereuropäischen Arten. *In*: Rabenhorst's Kryptogamen-Flora von Deutschlands, Österreich und der Schweiz **13**, Abt. 1, Lief 3, 4: 376-712, pls. 1-96. Nägeli, C. 1849. Gattungen einzelliger Algen physiologisch und systematisch bearbeitet. 139 pp., 8 pls. Nisizawa, K. & M. Chihara (ed.) 1979. Methods in phycological studies. 754 pp. Tokyo (in Japanese). Pringsheim, E.G. 1946. The biphasic or soil-water culture method for growing algae and flagellata. J. Ecol. **33**: 193-204. Ralfs, J. 1848. The British Desmidieae.

226 pp., 35 pls. London.

*　　*　　*　　*

Pleurotaenium（コウガイチリモ属）は広く世界各地に分布する淡水産緑藻類で，これまでにおよそ50種が知られている。*Pleurotaenium* は Nägeli (1849) によって設立されたが，現在多くの研究者に受け入れられている属の概念は Grönblad (1924) によって変更されたものである。Grönblad による属の概念の変更理由は，それまで所属が不確定であった数種を *Pleurotaenium* に属させるためであった。これら数種は，後に Krieger (1937) が "*minutum*-group" としたものである。今回，日本各地から集められた多数の液浸標本及び培養標本にもとづいて詳細な観察を行い，次の結果を得た。1) *minutum*-group の細胞壁に見られる粘液孔 (mucilage pores) は，本来の *Pleurotaenium* のものに比べ，あきらかに直径は小さく，分布が高密度である。2) *minutum*-group の葉緑体は基本的には半細胞中央に1本で，その長軸上にピレノイドが一列に並ぶいわゆる "中軸性" であるのに対し，本来の *Pleurotaenium* では，一列のピレノイドをもった常に複数の葉緑体が細胞壁に接するように位置する "側壁性" である。3) これまでに報告されている *minutum*-group の接合胞子は，全体が大きな瘤状突起で被われているのに対して，本来の *Pleurotaenium* の接合胞子の表面には瘤がなく平滑である。さらに，今回得られた *Pleurotaenium* の熟した接合胞子の全てに発芽口が観察され，中層の膜（mesospore）の外側表面には多数の乳頭状突起が観察されたが，これらの形質は *minutum*-group では知らされていない。以上の結果から *minutum*-group を *Pleurotaenium* に属させることは不適当と判断し，新属 *Haplotaenium*（ヒトツオビコウガイ属；新称）を設立し，ここに属させることを提案する。

□Kanda Hiroshi: **Catalog of moss specimens from Antarctica and adjacent regions** 176 pp. 国立極地研究所，東京．非売品．神田啓史氏の編集になる極地研所蔵の約6000点のコケ類標本のリストで，電算機により記録編集されたものである。一点のレコードは属・種・地域・経緯度・高度・所蔵機関・採集者・採集日付・同定者・同定日付・登録番号など13項目にわたる。リストでは項目の頭をそろえて見やすくしてある。リストは植物区系ごとに蘚類・苔類に分け，その中は科でまとめて属種の abc 順に配列されている。科以上のデータは一点づつのレコードに含まれていないようなので，この配列を得るには，裏にかなりの工夫があったものと推察する。またシステム的には必要に応じて項目検索をおこない，さらにくわしい記述のあるラベルの出力も可能であるとのことである。　　（金井弘夫）